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Melbourne, Florida 32901

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MAPPING: CITY OF PALM BAY, FLORIDA Final
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16. Abstract The Florida Local Comprehensive Planning Act requires each community in the state to prepare land use and land cover maps for their community. The maps for the City of Palm Bay, Florida, were developed with the assistance of Landsat multispectral scanner computer compatible magnetic tapes. Two different computer systems are compared for use in making land use and land cover maps. The Honeywell 635 with the Landsat Signature Development Program (LSDP) produced a map depicting general patterns, but themes were difficult to classify as specific land use. Urban areas were unclassified. The General Electric Image 100 produced a map depicting eight land cover categories classifying 68% of the total area. Ground truth, LSDP, and Image 100 maps were all made to the same scale for comparison. LSDP agreed with the ground truth 60% and 64% within the two test areas compared and Image 100 was in agreement 70% and 80%.							
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Final Report
Land Use and Land Cover
Mapping - City of Palm Bay, Florida

NASA Applications Projects Branch
City of Palm Bay, Florida

Submitted by Diane D. Barile
Robert Pierce
Center for Coastal Zone Research
Florida Institute of Technology

November 1977

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Land Use and Land Cover Mapping

City of Palm Bay, Florida

Abstract

The Florida Local Comprehensive Planning Act requires mapping of existing land use, and land cover for each local community in the state. Maps of regional land cover and land use were created prior to initiation of this project. This study produced five maps for the City of Palm Bay, Florida. These city maps will become part of the coastal protection element of the Local Comprehensive Plan for Palm Bay.

Ground survey maps of the Palm Bay region were based upon infra-red photography and ground survey. The Landsat Signature Development Program (LSDP) produced a map depicting general patterns, but themes were difficult to classify as specific land use. Urban areas were unclassified. The IMAGE 100 program with user designated themes, produced a map depicting eight land cover categories classifying 68% of the total area. Ground survey, the LSDP and IMAGE 100 maps, all at the same scale, were produced. These were compared by grid for two test sites. Efficiencies of 60 - 64 percent were recorded for LSDP and 70 - 80 percent were recorded for the IMAGE 100.

A Vegetation (land cover) map, an Existing land use map and a map of Areas of Particular Concern were generated from the preliminary maps. These final maps were redrawn from the regional land cover and land use maps but contained only areas within the city of Palm Bay.

Diane D.Barile

Center for Coastal Zone Research

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1.0 Introduction

- 1.1 The City of Palm Bay, Florida and the Science, Technology and Applications Group at NASA, Cape Kennedy entered an agreement with the Center for Coastal Zone Research at the Florida Institute of Technology for the development of land use and vegetation maps of the city. NASA facilities and expertise were used to analyse LANDAT imagery and refine maps for inaccessible areas of the city. NASA also provided reproductions of maps in the form of slides and color prints. The Center of Coastal Zone Research provided ground truth information and interacted with NASA personnel and equipment in generation of maps, analysed data and prepared monthly and final reports.
- 1.2 This final report outlines the methods, procedures and results of the study. These results will also be included in the coastal zone element of Palm Bays land use plan.

2.0 Purpose

2.1 The Local Government Comprehensive Planning Act of 1975 directs each city in Florida to prepare a comprehensive land use plan by July 1, 1979. One element of the plan for coastal cities is a Coastal Protection Element.

2.2 A survey of existing vegetation and coastal resources is among the requirements for the completion of the Coastal Element. In addition, a survey of critical wildlife habitats and an account of living and non-living coastal zones resources is necessary. Each city's plan is to be co-ordinated and inter-active with others of the region. For this reason the study area included portions of adjoining cities.

2.3 The purpose of the Palm Bay - NASA project is, therefore, threefold. First to survey vegetation and land use patterns within the city. Second to map these uses as a part of the coastal zone element. And third, to analyse the accuracy of the remotely sensed information as compared to detailed ground truth for two test sites.

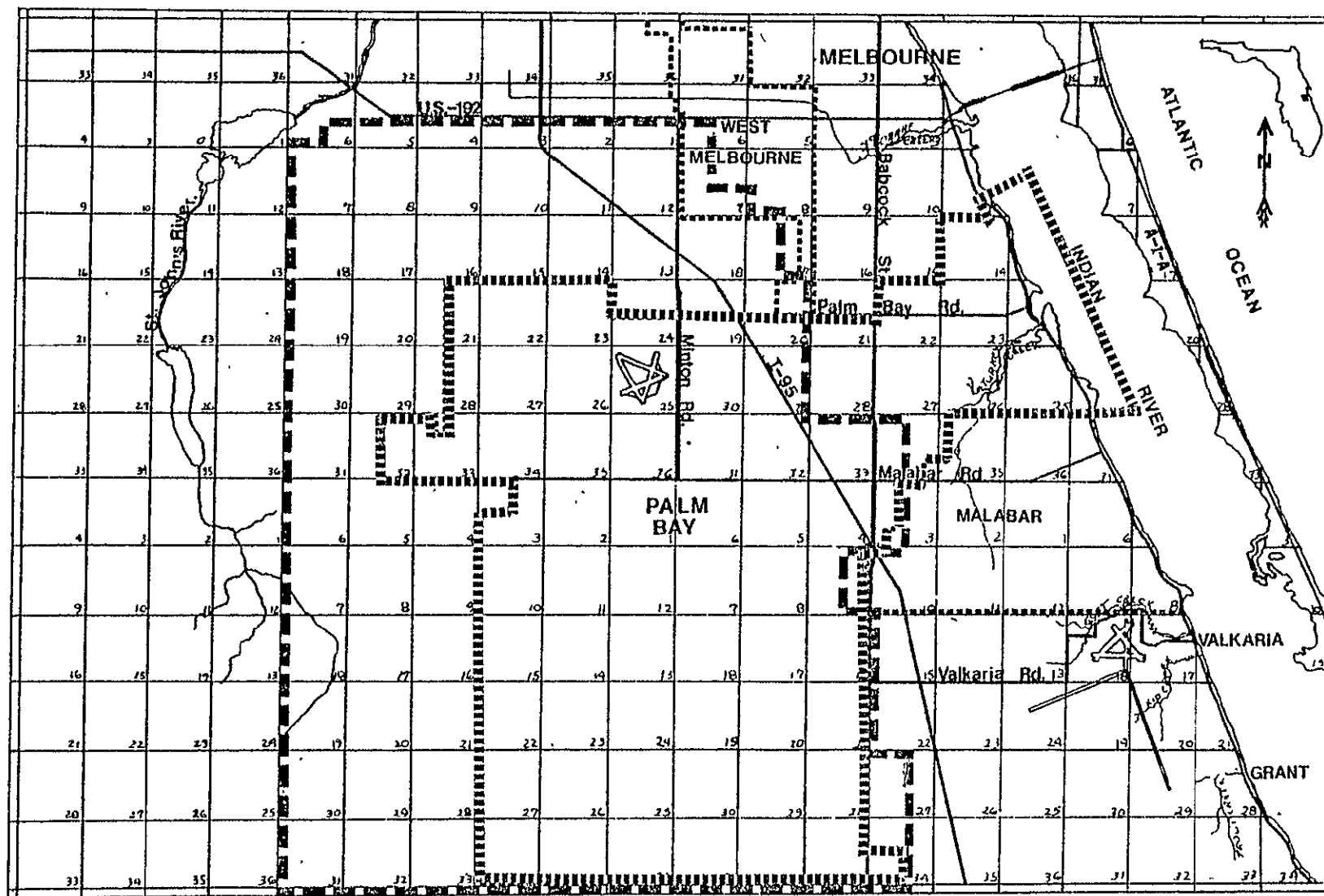
3.0 Study Area

3.1 Analysis of land cover and existing land use were conducted on a regional basis. The preliminary ground truth mapping and subsequent computer analysis of LANDSAT imagery was carried on at this larger scale. This allowed a greater range of spacial patterns and ecosystem types for comparison. All maps were drawn at the same scale 1:24,000 and could overlay the U.S. Geological Survey 7.5 minute topographic maps.

3.2 The regional study area extended from US 192 on the north to the Atlantic Ocean on the East. The Western boundary was the St. Johns River, the southern limit was the south Melbourne-Tillman Drainage District (MTDD) levee. The study area included unincorporated areas of Brevard County, the MTDD, as well as the cities of Melbourne, West Melbourne, Malabar, Melbourne Beach and Indialantic.

3.3 The Final maps prepared for the city of Palm Bay included only those areas within the city limits. The city of Palm Bay, Florida is located in East Central Florida south of Cape Kennedy in Brevard County (Figure 1). The eastern boundary of the city is the Indian River, an estuarine lagoon separated from the Atlantic Ocean by a long barrier island.

The ridge, high ground thirty-five feet above mean sea level, geographically and hydrologically divides the city.



Study Region and
Figure 1 - Location of Palm Bay

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3.3 -Continued

The initially developed portions of Port Malabar mark the southern limit of the eastern boundary. South of Malabar Road the majority of the city lies west of Atlantic Coastal Ridge.

3.4 The southern boundary follows a line from Melbourne-Tillman Drainage District Levee to Babcock Street. It extends and includes a quarter section East of Babcock.

3.5 The western boundary of the city is set from 6 to 7.5 miles west of Babcock Street. The land is gently sloping prairie and marsh which have been drained for agriculture and urban development.

3.6 The northern boundary of the city abuts the cities of Melbourne, West Melbourne and unincorporated portions of Brevard County. It extends from the Indian River to US 1, along the Florida East Coast Railroad Casement, then west to the Areas north of Palm Bay Road. West of Babcock the boundaries follow Palm Bay Road, then extend north to include the Melbourne Poultry Colony

3.7 The City includes some sixty-four square miles of land extending west to the St. John's River marsh and south some eight miles along the Atlantic Coastal Ridge. Turkey Creek, a fresh water stream, meanders from wetland tributaries east of the coastal ridge to a wide bay hence into the Indian River. The Melbourne-Tillman Drainage

3.7 Continued

District, a system of canals and levees, drains land west of the coastal ridge and discharges water into Turkey Creek. The city is also dotted with wetland sloughs, marshes, ponds, borrow pits and hardwood hammocks.

3.8 Vegetation patterns within the city are determined by water availability, soils, elevation and degree of succession. Generally the coastal ridge, the highest elevation in the city (36 ft. MSL) are covered by pine flatwoods, sand pine or scrub. In these areas, if clay or hardpan soils are near the surface, grassy sloughs or ponds result.

3.6.0 Test Sites

3.6.1 Two sites within the study region were selected for detailed land use and vegetation analysis. These four square mile sites were selected to represent in one case the most homogenous land use in the region and in the other the most varied.

3.6.2 Site I, the most homogenous (figure 2), is found adjacent to the southwest corner of the city. The area is primarily pasture interspersed with maple-bay heads, drainage canals and ponds. Site II is centered in the large hammock at the headwaters of Turkey Creek. Land use is mixed. It includes some graded land, residential areas, sandpine ridges and wire grass sloughs.

3.63 The test sites selected also represent areas which have had few changes between the October 1974 imagery and the 1977 ground truth. Vegetation types are stable. The hammock site is a climax forest and the pasture area has maintained the same land use. Differences in water table alteration or other agricultural practices may have influenced results to some extent.

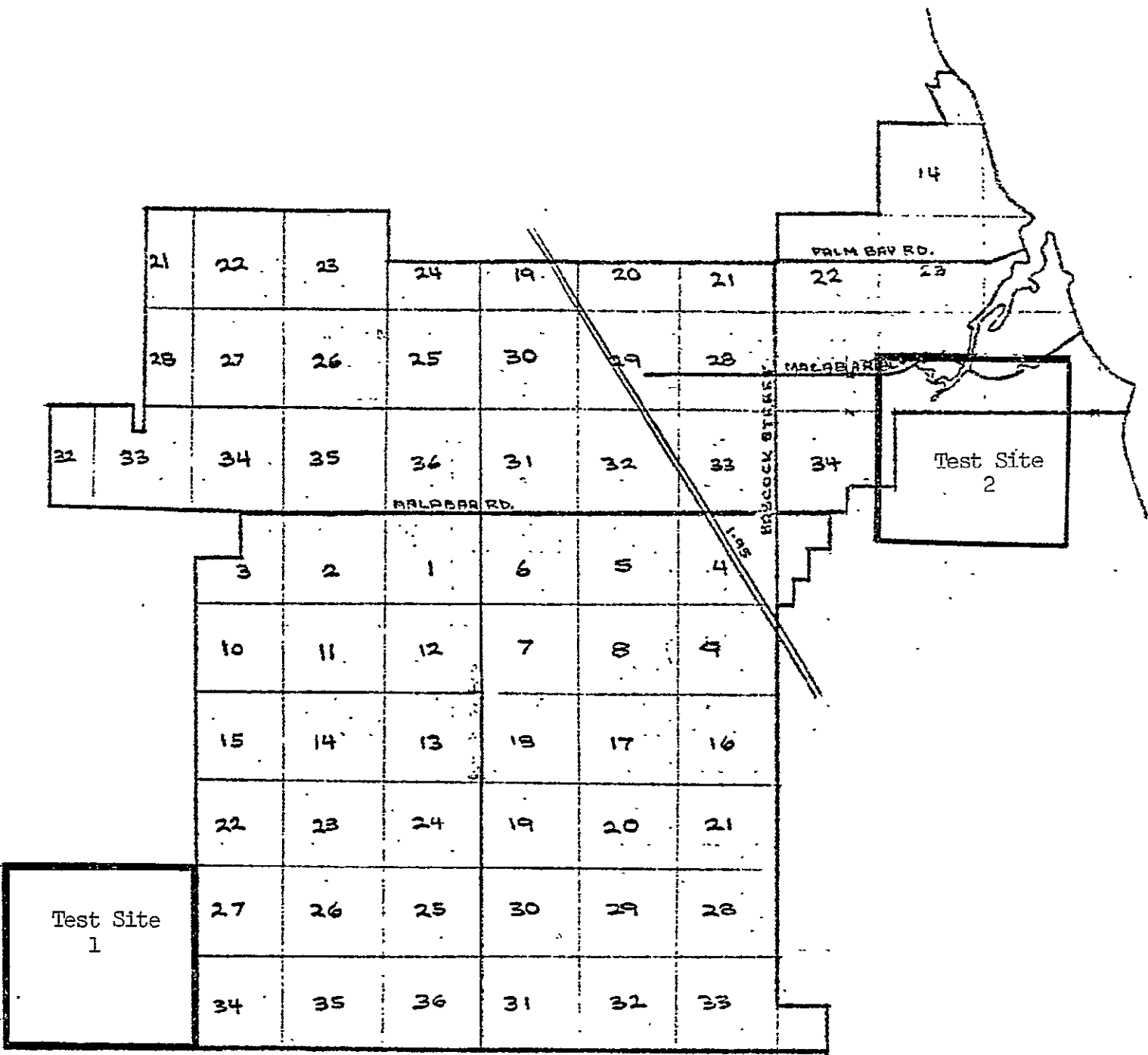


FIGURE 2

TEST SITES FOR GRID ACCURACY ANALYSIS

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4.0 Methods

4.1.0 Mapping

4.1.1 Seven maps were produced during the course of the study (Table 1). All seven were drawn at the same scale 1:24,000. Two were working maps; the vegetation map and the land use map. Two were computer generated; the LSDP map and the IMAGE 100. All four of the maps mentioned above were regional in scope, covering an area larger than the City of Palm Bay. The vegetation map and land use maps were drawn to overlay four U.S. Geological Survey 7.5 minute maps. Thus portions of the city of Palm Bay were a part of each sheet. The final maps for presentation to the Palm Bay were a composite of the portions of the working maps inside the city limits; the vegetation map and the Land Use Map. The map of areas of particular concern was produced from analysis of the above mentioned six maps.

4.1.2 The LANDSAT imagery used was dated October 19, 1974. The infra-red photographs used for preliminary mapping of the two ground truth maps were dated 1973-1974. These maps were updated to 1977 conditions by ground truth and current aerial photographs.

In the following portions of this section mapping methods for each type of map are discussed. Following methods of classification and accuracy analysis are described.

TABLE 1 COMPARISON OF MAPS PRODUCED FOR THE PALM BAY NASA STUDY

Map	Scope	Purpose	Data Source	No. of Classifications Per Map	Basis of Classification	Scale
1. Land cover regional		Environmental	1. Mark Hurd, 1974 infra-red aerial photography, black and white and color 2. ground survey 1977 3. aerial survey 1975*	35	Visual Patterns on Infra-red Photographs	1:24,000
2. Land use regional		Existing type of development for human use	1. Mark Hurd, 1974 infra-red aerial photography black and white and color 2. ground survey 1977 3. aerial survey 1975	19	Visual Patterns on Infra-red Windshield Survey	1:24,000
3. LSP regional		Computer set themes based upon groupings of wave lengths	LANDSAT Oct. 1974	8	Unsupervised computer assignment based upon clustering algorithm	1:24,000
4. IMAGE 100 regional		Mapping of region based upon user selected themes	LANDSAT Oct. 1974	8	User selected themes based upon general representative land use types	1:24,000
5. Land cover (Palm Bay)		Final vegetation map for Palm Bay	All of the Above	24	Same as 1 above	1:24,000
6. Land use (Palm Bay)		Final Land use map for Palm Bay	All of the Above	19	Same as 2 above	1:24,000
7. Areas of Particular Concern (Palm Bay)		Map of vital areas requiring special management	All of the Above	11	Based upon all of the above and survey coastal resources	1:24,000

4.2.0 Ground truth land use maps.

4.2.1 Maps of land use and vegetation cover (Table 1)

were produced at a scale of 1:24,000. Base maps were prepared using 1973 Mark Hurd black and white aerial photographs (scale 1:24,000). Base maps were drawn on .003 inch polyester/matte to over lay each U.S. Geological Survey Topographic Map containing portions of the city; four in all. Major physical and environmental features were delineated. Magnified Mark Hurd false color infra-red aerial photography (1 inch: mile) were used to further refine details.

4.2.2 In many cases a specific land use could not be classified even though clearly defined on the photographs. These areas were marked and land use designated by ground survey by car, truck or boat or airboat. In addition maps were updated using ground truth surveys to reflect land use changes which occurred between the 1973 Mark Hurd photography and July 1977.

4.2.3 The method of land use classification depends upon the level of detail included on the map and the function of the map. On the initial set of maps land use was designated according to visual differences between black and white as well as false color infra red photography. This lead to the delineation of thirty-five land uses.

4.2.4 The existing land use map of the city features detailed classifications of urban land use into specific uses and densities. Residential use was depicted as low or medium density, multi-family, or mobile home. Major transportation and utility right of ways are depicted and agricultural land categorized as crop land, citrus groves, nursery or pasture, improved or unimproved.

4.2.5 The Vegetation map of Palm Bay was prepared from the adjacent U.S. Geological Survey maps of the areas within the city boundaries. This map was classified as to dominant vegetation cover. In areas where vegetation patterns were modified separate categories were created. For example: areas of undisturbed pine flat woods were placed in one classification. Other areas were obviously pine flatwood but were interspersed with streets or scattered houses. These areas were placed in a separate category; graded land.

4.3.0 LANDSAT Signature Development Program Map

4.3.1 The LSDP program was used to generate a map of the regional study area based on LANDSAT data, Oct. 19, 1974 consistent with that used for other mapping efforts in this study. The map is the product of a computer program for the unsupervised classification of remotely sensed information from a LANDSAT tape. This statistical method of theme designation is based on the clustering tendency of multispectral scanner data. The mapping program assigns classifications or themes through a clustering algorithm based on maximum likelihood of occurrence. It assigns class characters to pixels within three standard deviations of the class means and resolves overlap between classes via the maximum likelihood rule.

4.3.2 The Palm Bay regional LSDP map was composed of 8 classifications at a 96 percent confidence level. The categories were limited to eight in order to facilitate comparisons with the eight theme limit on the IMAGE 100.

4.4. IMAGE 100 Mapping

- 4.4.1 A map of the study area was prepared using the multi-spectral image data obtained from the LANDSAT I October 1974. This is consistent with imagery used for the LSDP analysis and covers the same time period as the photographs used for ground truth mapping. The General Electric IMAGE 100 digital processing system was used to map eight land use categories at a scale of 1:24,000. Each Land use was assigned one of the available eight channels on the IMAGE 100. Land use designation was based upon a representative land use selected as a training site determined by previous ground truth. The eight categories represented major groupings of the 35 land uses depicted on the ground survey maps.
- 4.4.2 Preliminary exercise of IMAGE 100 produced a map of characters at a scale of 1:27,000. There was difficulty in overlaying of land use maps due to skew in the IMAGE 100 map. A skew factor and change in scale were incorporated into the subsequent analysis by NASA personnel.
- 4.4.3 Analysis produced composite maps of 8 themes at a scale of 1:24,000 corrected for skew with larger percentages of total coverage. One page printouts of individual themes were also produced.

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4.5.0 Accuracy Analysis

4.5.1 The general design for the analysis of the accuracy of the maps generated from machine processed LANDSAT imagery was to grid two, four square mile areas on the LSDP map, the IMAGE 100 map and the ground truth map. Comparisons were then made grid per grid between the two computer maps and the ground truth information.

4.5.2 Ground truth for test sites.

Detailed ground truth surveys, plotting of individual true and vegetation types, were undertaken within the test sites rather than mapping of general community types as in earlier maps. In site I, the homogeneous pasture area, field observations and aerial photography (Mark Hurd) provided the basis for mapping. In site II the patchy area centered on the Turkey Creek hammock incorporated use of aerial photography and vegetation analysis. Because of the patchy nature of Eastern Florida coastal vegetation the point centered quarter methods of Dubois-Muller was employed. These surveys provided information on species, density and frequency of occurrence. Low level false color infra red photography supplied by NASA were used to finalize the maps.

4.5.3 Grid designation

4.5.3.1 Three methods of grid determination were explored.

The area of the ground truth map was divided into 4 mile

4.5.3.1 continued

square plots of 100 grids each representing 6.4 acres.

This method was well adapted to the ground truth map but not to the LSDP theme printouts. The grids did not correspond to the placement of pixel on the theme maps. Characters were bisected by grid lines.

4.5.3.2 The grids were then modified to contain six characters on the LSDP theme map. Grids therefore represented 6.72 acres or 2688 acres. This area is slightly larger than the 2560 acres of the original grids. Ground truth information was modified to the new grid system.

4.5.3.3 A further interpretation was necessary for the analysis of IMAGE 100 data. Skew factors were incorporated into the program, however, character alignment did not place north on a perpendicular axis. Characters displayed by the printer were therefore at an angle relative to the axis of the grids. The number characters represented per grid therefore, varied in the IMAGE 100 grid analysis. The area surveyed by the grid was still the four square miles of 400 grids and included presumably the same number of characters.

4.5.4.0 Grid Placement

4.5.4.1 Grid placement was accomplished by aligning the ground truth land use map over the computer maps. Roads and canals served as the major reference sites. Alignment

4.5.4.1. continued

could be verified by checking siting and comparing other established features. Land use differences on either side of roads were useful in determining alignment.

4.5.4.2 Geographic registration, the ability to match particular pixel to the exact land use it represented was a difficult task. As maps were generated specific patterns took form. Roadways, particularly I-95, borrow pits and major canals became landmarks. Ground cover maps were placed so as to match these features. Placement could have been shifted one or two pixels in any direction.

4.5.5 Land use assigned per character

4.5.5.1 The three land use maps (the ground truth, LSDP and IMAGE 100) were classified using different themes. In the case of the LSDP, the unsupervised program, produced themes requiring interpretation by the investigator. The eight themes of the IMAGE 100 map included the 35 classifications of the ground truth maps. Classifications from ground truth were grouped by general classifications as listed on Table 6.

For the LSDP theme map, land use was assigned to each character basic upon the random comparison to observed land use features. This method was refined following preliminary analysis.

4.5.5.2 For final accuracy analysis of the LSDP program

the theme printout was overlain by the ground truth land use map for the test sites. The frequency of occurrence of each character as compared to ground truth was established. The land use for the theme was therefore assigned as that with the highest frequency of occurrence.

4.5.5.3 The thirty-five land use classifications of the ground truth maps were grouped to form eight categories similar to those used as training sites for the IMAGE 100 mapping

4.5.6.0 Recording of land use by grid. Land use for each grid was recorded on a series of data sheets, one sheet per horizontal column. Each grid was therefore assigned an alpha numeric designation. This had no correspondence to the alpha numeric symbol on the printout.

4.5.6.1 Ground truth map was recorded from the detailed land cover or vegetation maps. Land use maps describing housing types and urban uses were not of value for comparison. Preliminary analysis recorded the dominate land cover per grid. This was modified to list other prominent features within the grid, ponds, roads or major canals.

4.5.6.2 LSDP characters were recorded only as the dominate land cover in each grid. Unclassified or blank pixels were recorded. If no clear dominance prevailed a

4.5.6.2 continued

designation for mixed use was recorded. This method did not account for small but readily distinguishable land use features discernable both on the ground truth and the LSDP theme map. The method was modified to record the dominate character per grid as well as all other characters in the grid by descending number of occurrences.

4.5.63 IMAGE 100 theme characters were recorded as they occurred per grid using the modified recording method described for the LSDP. Since the characters were not aligned on a north-south axis the number of characters per grid varied. The same protocol applied to the LSDP grid, analysis was extended to include these additional characters. The assumption was made that those characters touching the top or left gridline were within the grid, those touching the bottom or right gridline were not.

4.5.7 Ground truth was compared on a grid by grid basis to the LSDP and then the IMAGE 100 map. A plus (+) was recorded for a positive comparison, a (-) for lack of agreement. The total number of grids in agreement was divided by the total number of grids producing the percentage of efficiency or accuracy.

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5.0 Results

5.1.0 LSDP map

5.1.1 The Landsat Signature Designation program produced composite map of eight themes at a scale of 1:24,000 (figure 3.). The themes were based on the tendency of multispectral scanner data to cluster about certain statistically determined loci. A land use classification was assigned each theme as determined by frequency of occurrence compared to ground truth. The number of pixels and percentage of the total area classified are included in Table 2.

5.1.2 Deep water of rivers, lakes and streams occupied the largest area. Shallow water areas were classified in a separate category. Dense vegetation or drainage were outstanding features of the map. Wire grass sloughs and open space were also classified.

5.1.3 Urban land use was for the most part non-classified. Visually these areas were significant when framed by the classified theme. Areas unclassified were identified. as: major roads systems, I-95, medium density areas of residential development, borrow pits, airport runways, crops, spoil island and major drainage canals. The clear delineation of these areas served as a means of identifying major land marks.

TABLE 2

LSDP

Total Study Area

Class	Number of Pixels	Symbol	Percent of Area	Landuse (frequency of occurrence)
1	78,549	/	29.05	deep water, Indian River
2	39,530	\$	14.62	hammock, dense pine, baccharis
3	14,697	+	5.44	pine scrub slough, poorly drained land few trees, open space
4	24,062	%	8.90	deep water
5	27,253	1	10.08	cleared, drained land, dirt roads, levees old field
6	8,823	*	3.26	improved pasture, old field, hammock pine flats
7	6,667	0	2.47	shallow water in sloughs of pine or pine scrub
8	3,997	#	1.48	slough in pine or pine scrub
Classified	203,578		75.30 %	
Unclassified	66,779 B		24.7 %	
Total	270,357			

FIGURE 3 LSDP MAP

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5.2.0 IMAGE 100 Map

5.2.1 The composite map of the Palm Bay - Melbourne

Tillman Drainage District area is presented as a photograph on 35mm color slides and as figure 4. One page printouts from the IMAGE 100 system are here included as figures 5 through 12.

5.2.2 Land use themes, areal statistics and percentage of total area coverage are recorded in Table 3. Water, wetlands and pinelands account for 45% of the total area classified. Unclassified areas include areas of the Indian River, golf courses and other open spaces.

FIGURE 4
IMAGE 100 Map of Palm Bay Region

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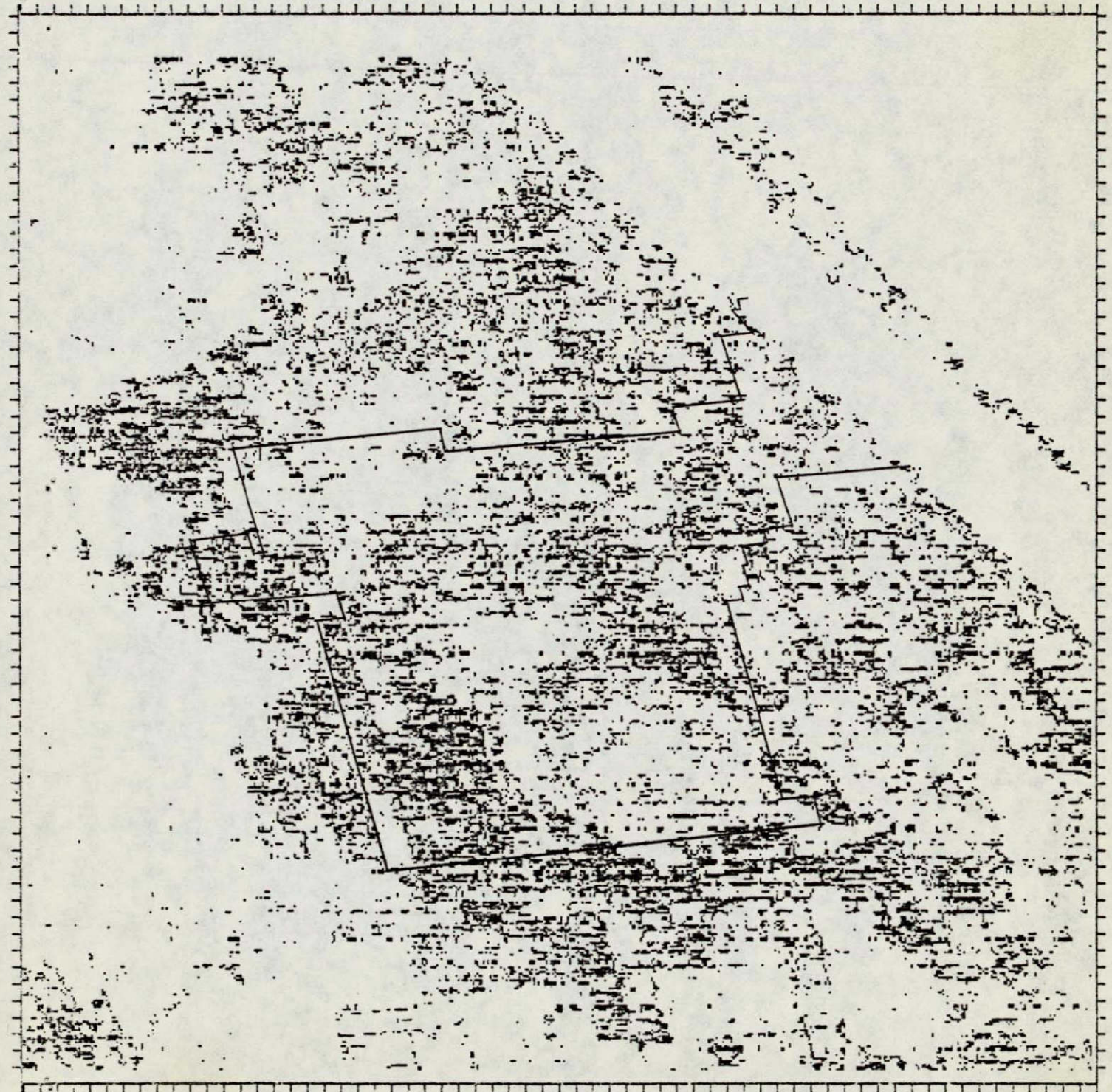


TABLE 3
IMAGE 100

Class	Number of Pixels	Symbol	Percent of Area	Results Land Use
1	36,580	!	14	Pineland (a)
2	6,752	"	2.6	Crops
3	49,341	*	18.8	Water
4	2,792	Ø	1.1	Recent urban
5	9,245	\$	3.5	Hammock
6	20,184	-	7.7	Established urban
7	31,328		12.0	Marsh/wetlands
8	<u>23,256</u>	%	<u>8.9</u>	Pasture
Classified	179,478		68.6 %	
Un- Classified	<u>82,152</u>		31.4 %	
Total	261,630			

FIGURE 5
Class I Pinelands

*** ONE PAGE THEMATIC PRINT - REV. A ***
*****COMPOSITE LAND USE PALM BAY/MTDD PINELAND (1)*****
KREP 35244, PIXELS: 13,931 THEMATIC TRACK 1 PRINTOUT DATE:01-JAN-72 PRINTOUT TIME:00:19:59

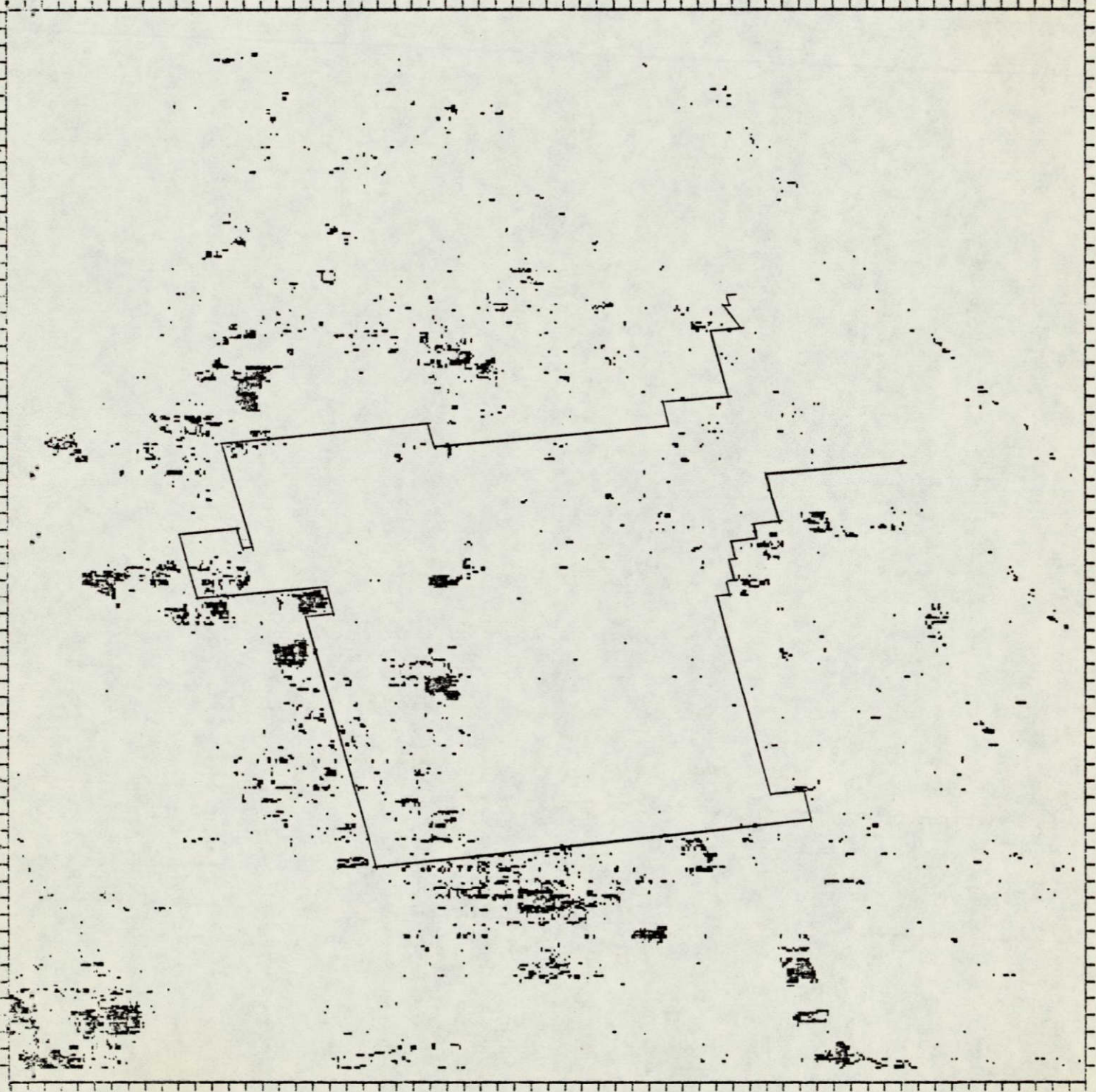


_____ Palm Bay Boundary

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Figure 6
Class 2 Crops

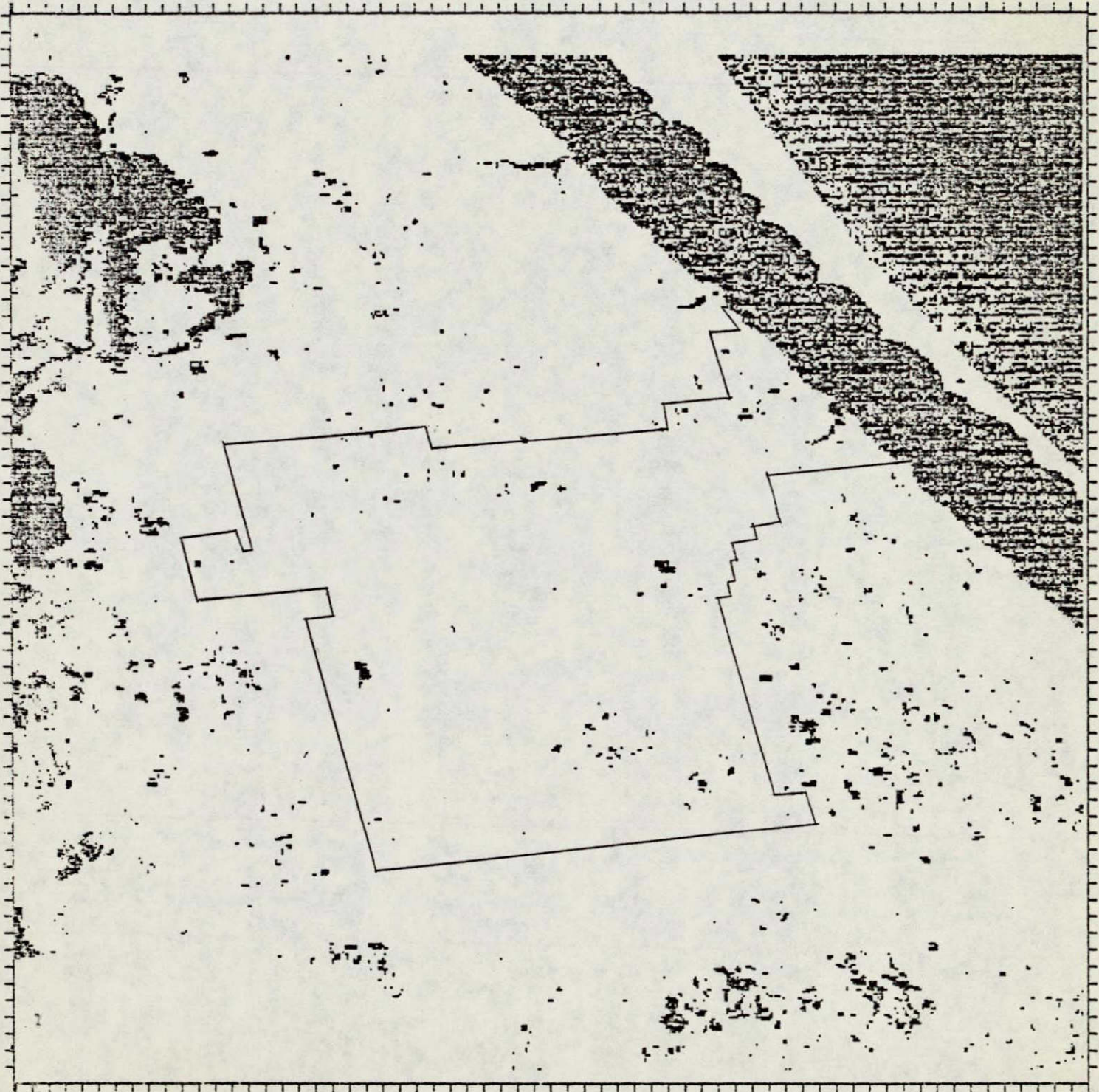
*** ONE PAGE THEME PRINT - REV. A ***
*****COMPOSITE LAND USE PALM BAY/MTDD CROPS (*****
AREA= 5304. PIXELS: 2.40% THEME TRACK 2 PRINTOUT DATE:01-JAN-72 PRINTOUT TIME:00:21:14



_____ Palm Bay Boundary

FIGURE 7
Class 3 Water

*** ONE MORE THEM POINT - KEY - H ***
*****COMPOSITE LAND USE PALM BAY/100 WATER (4)*****
AREA= 27346. PIXELS(14.25%) THERE TRACK 3 PRINTOUT DATE:01-JAN-72 PRINTOUT TIME:00:21:59



_____ Palm Bay Boundary

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Figure 8
Class 4 Recent Urban

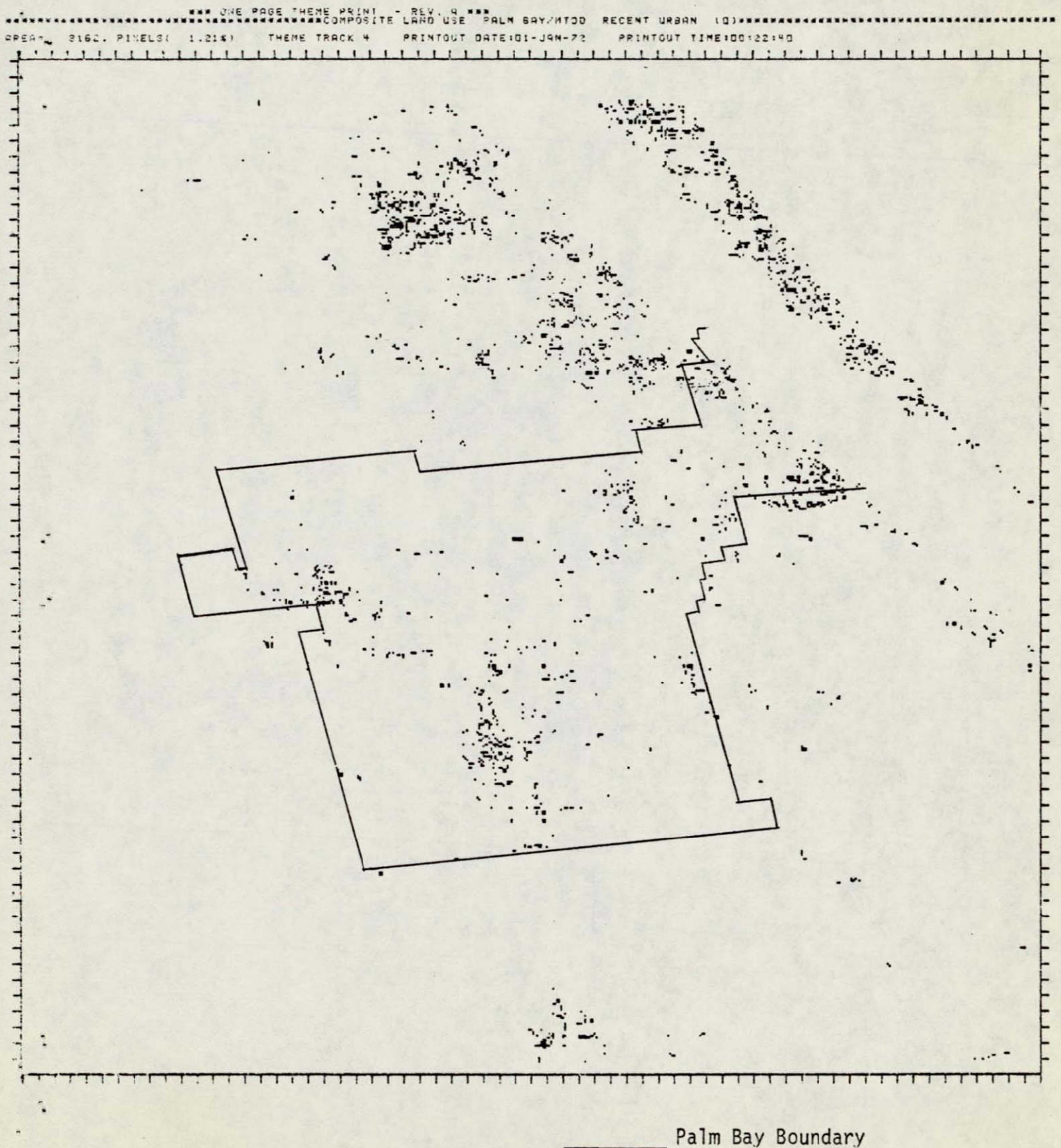


Figure 9
Class 5 Hammock

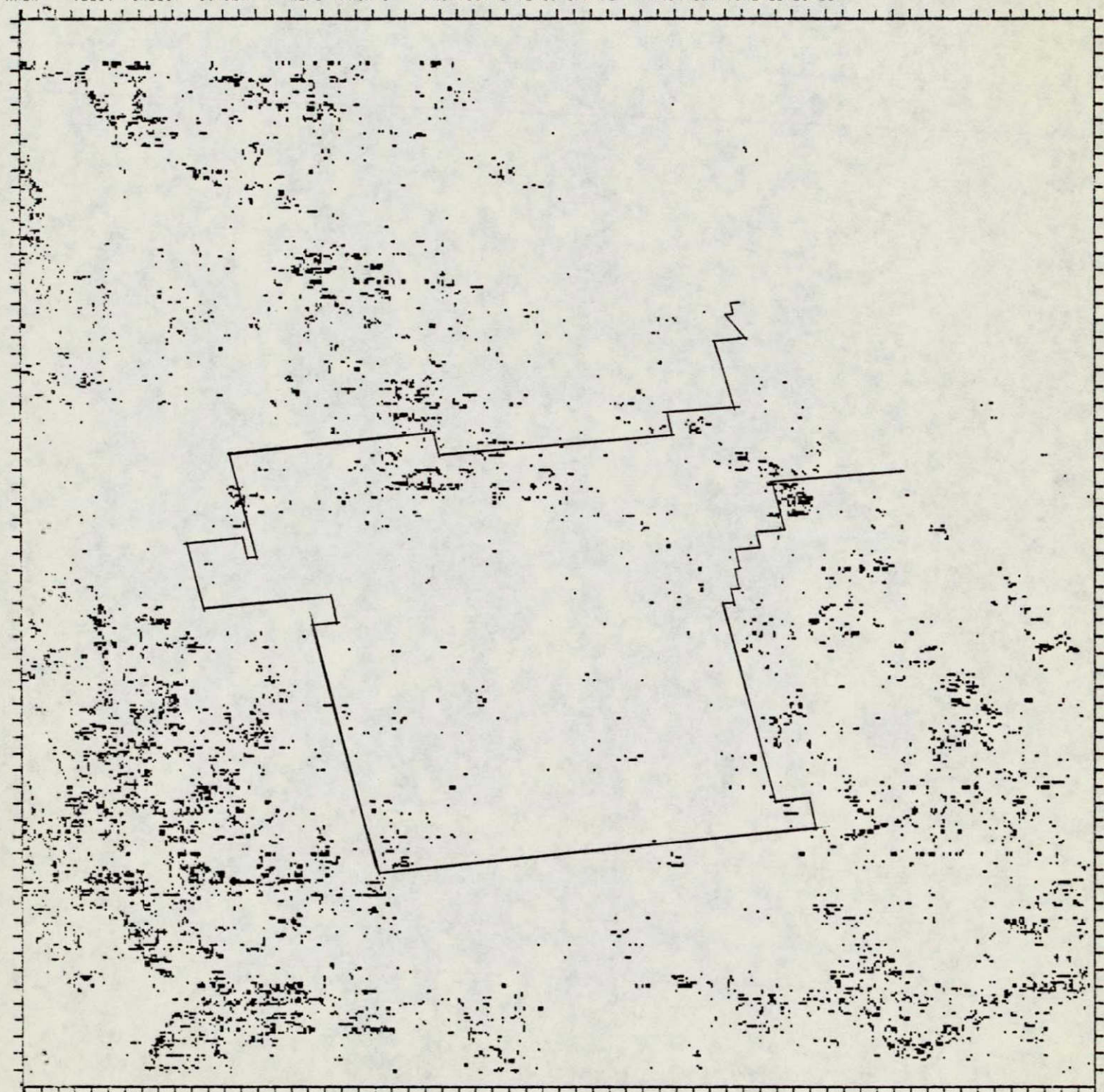
COMPOSITE LAND USE

#COMPOSITE LAND USE PALM SPRING/MTOD

HANNOCK (S)A

● 参考文献

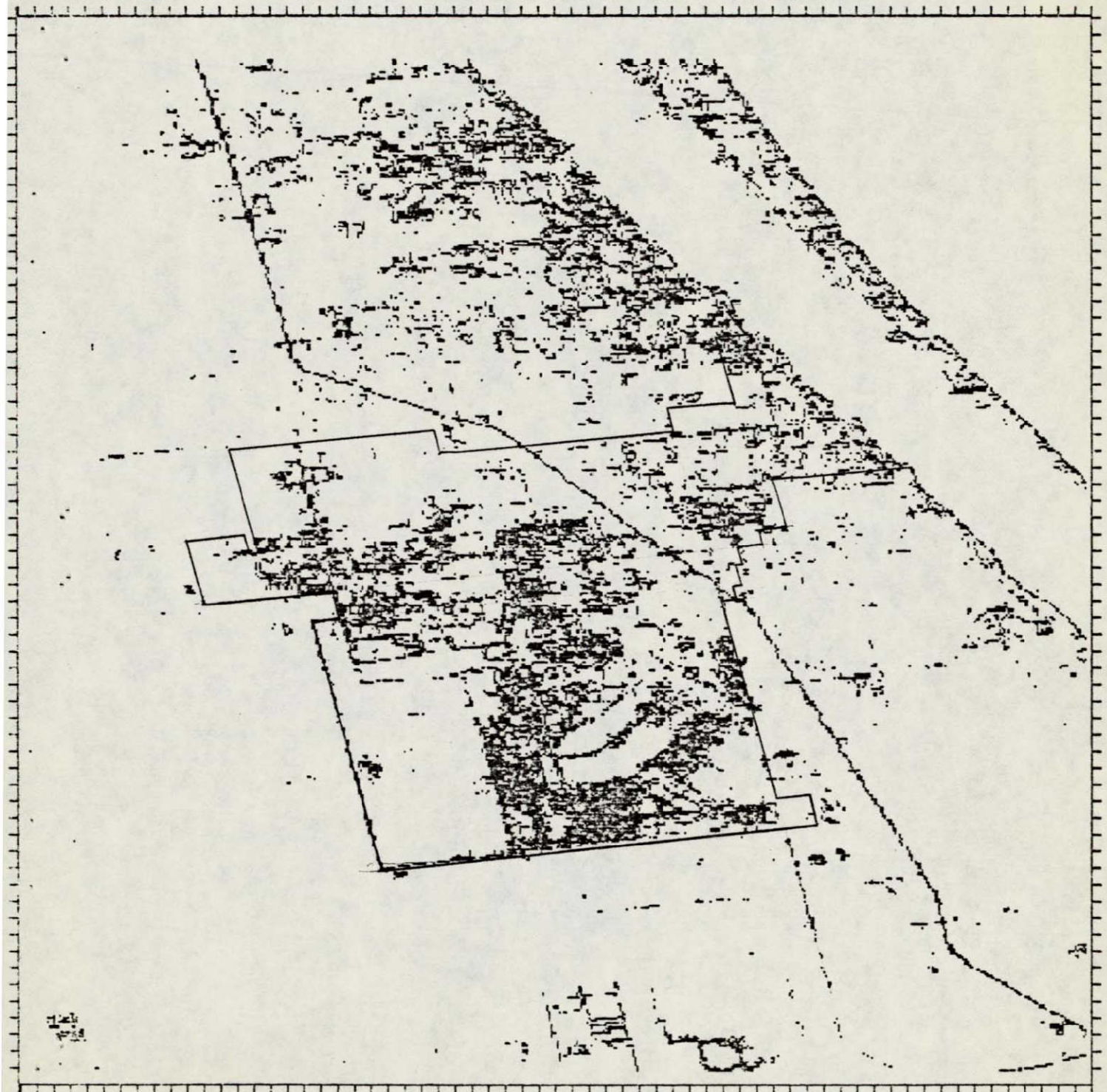
AREA= 9001. PIXELS(3.48%) THEM TRACK 5 PRINTOUT DATE:01-JAN-72 PRINTOUT TIME:00:23:20



Palm Bay Boundary

Figure 10
Class 6 Established Urban

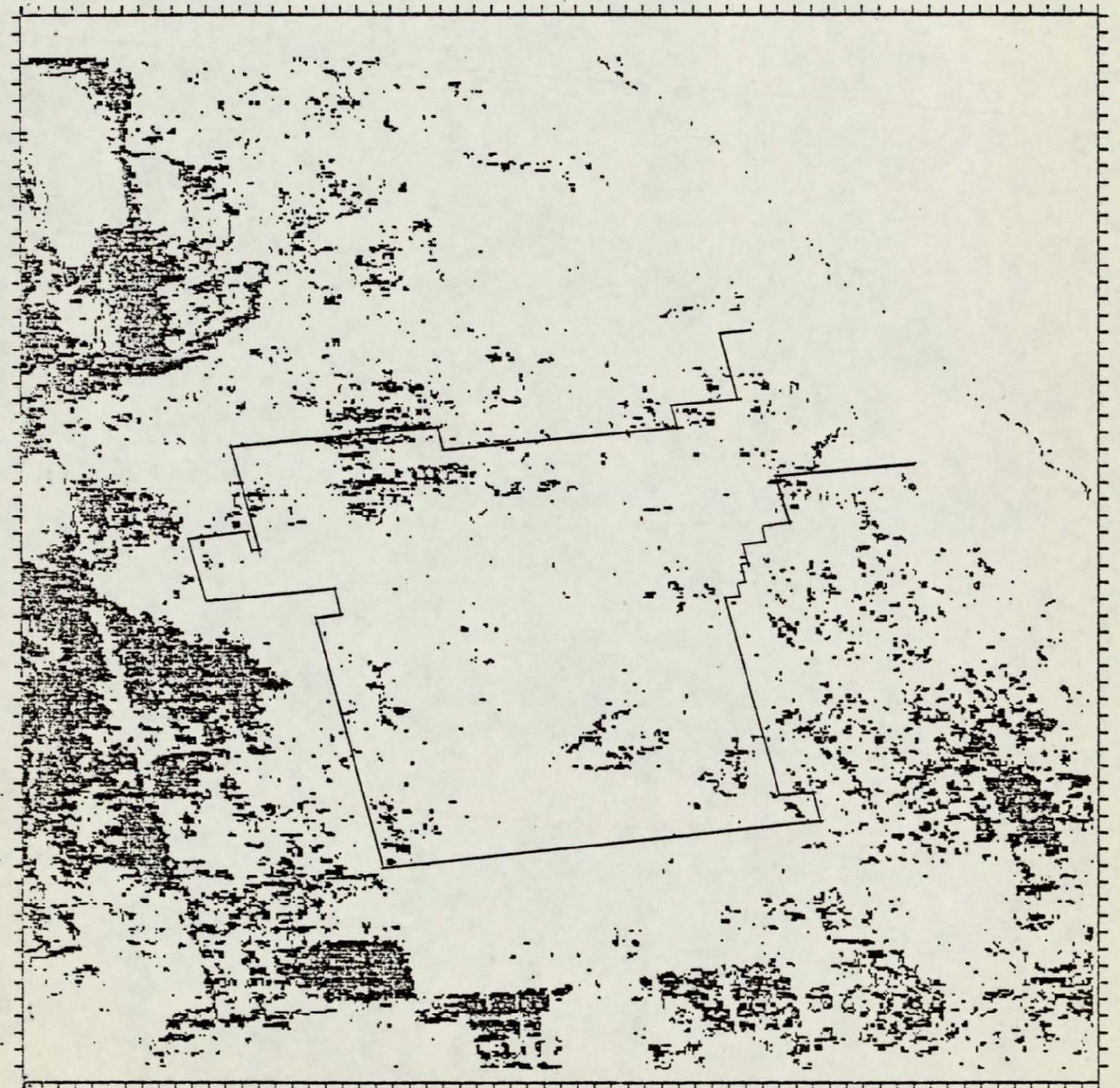
*** ONE PAGE HEAT PRINT - REV. A ***
*****COMPOSITE LAND USE PALM BAY/MTDD ESTABLISHED URBAN (-)*****
AREA= 29312. PIXELS(8.78%) THEME TRACK 6 PRINTOUT DATE:01-JAN-72 PRINTOUT TIME:00:23:59



_____ Palm Bay Boundary

Figure 11
Class 7 Marsh-Wetlands

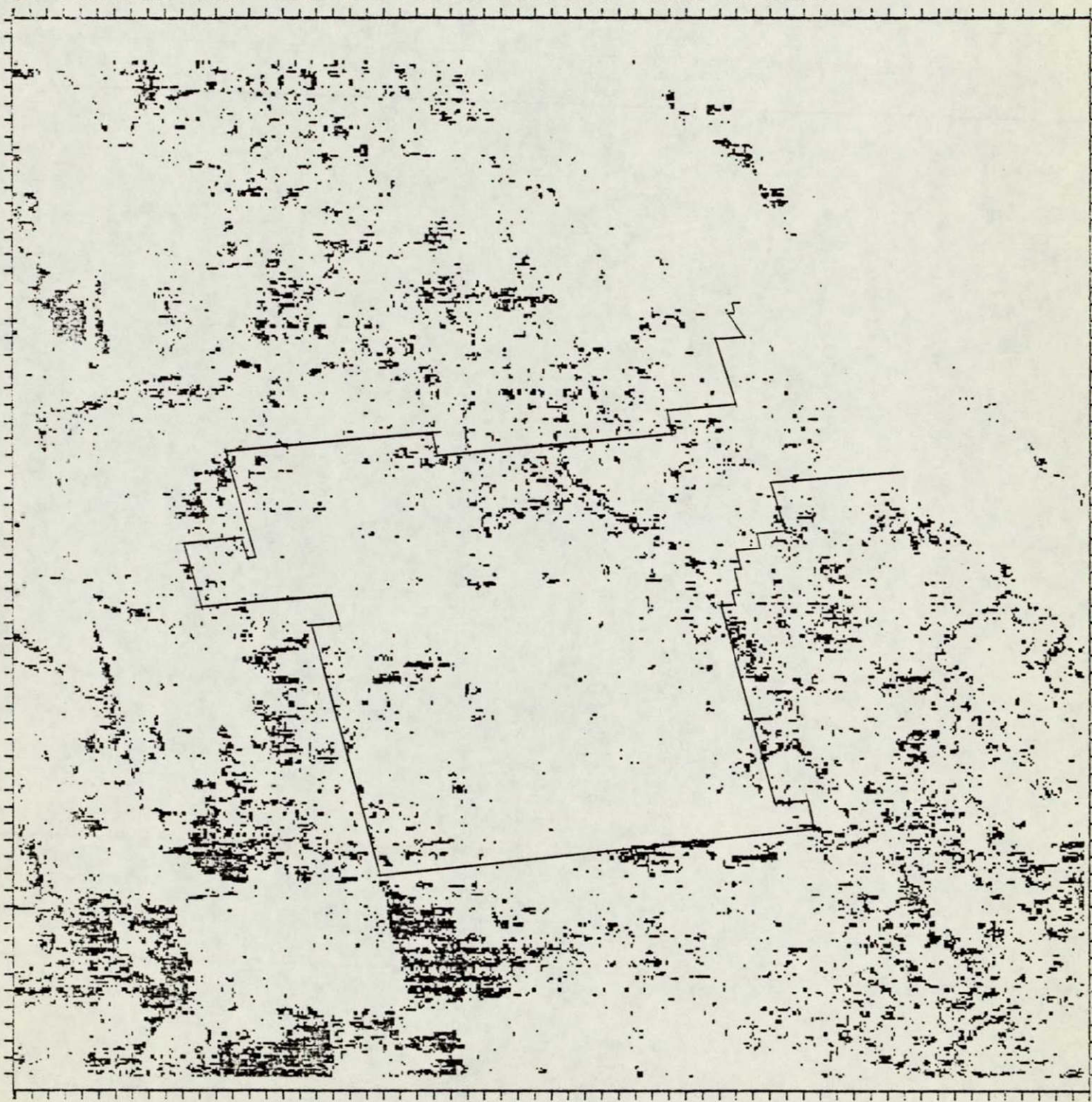
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*****COMPOSITE LAND USE PALM BAY/NTDD MARSH/WETLANDS (1)*****
AREA: 32620. PIXELS: 12.44% THEMATIC TRACK 7 PRINTOUT DATE:01-JAN-72 PRINTOUT TIME:00:24:43



— Palm Bay Boundary

CLASS 8 PASTURE

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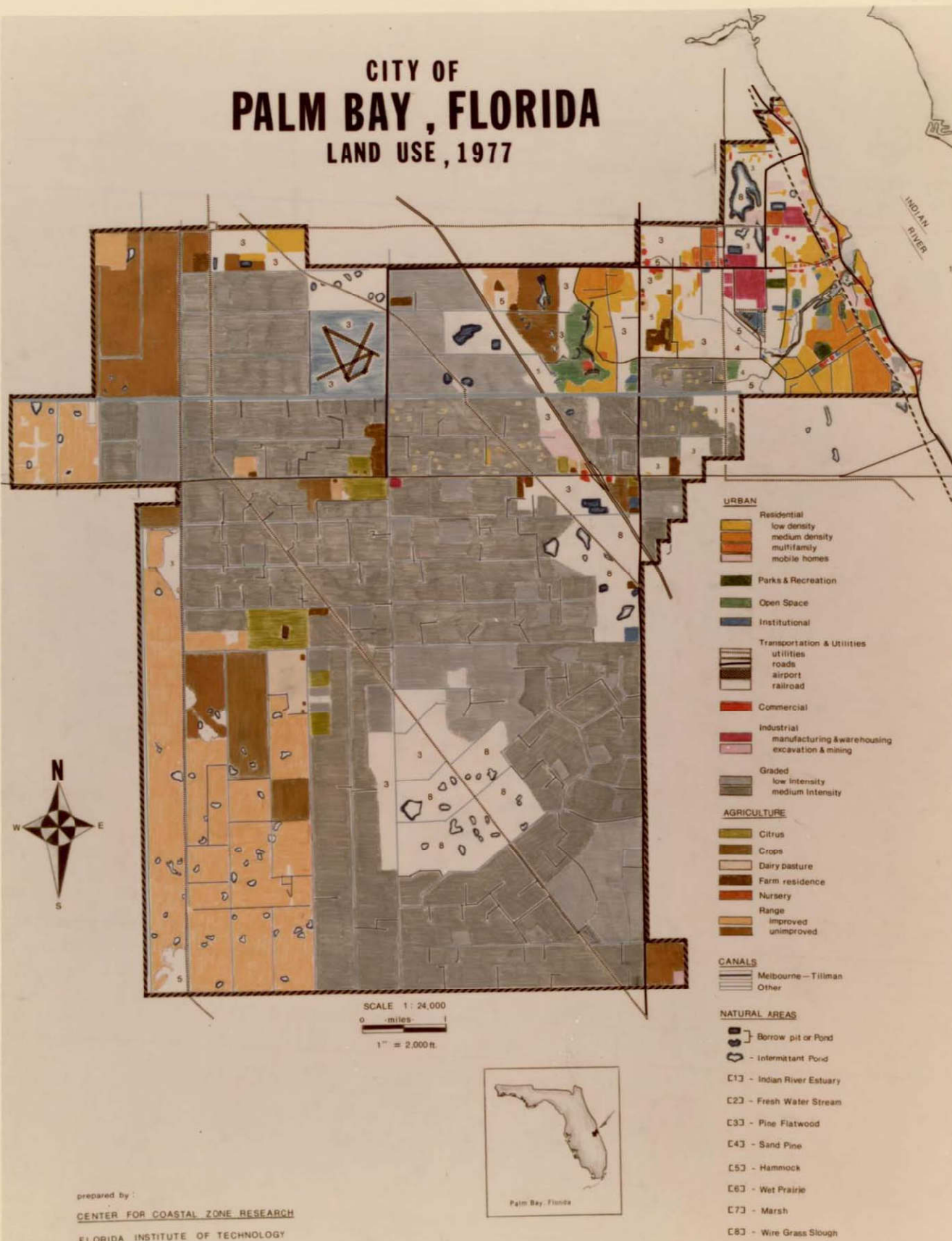


Palm Bay Boundary

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FIGURE 13

CITY OF PALM BAY, FLORIDA LAND USE, 1977



5.3.0 Vegetation Map of Palm Bay

5.3.1 The land cover of the City of Palm Bay is depicted in Figure 13. A description of the each plant community as described in the key is listed in Appendix I.

The categories as displayed on the land cover map are of necessity generalized. There may be some overlap. For instance areas marked pine flat woods may contain sloughs or ponds, small hammocks in unimproved pasture may not be displayed.

5.3.2 The largest percentage of land cover in the city (figure 13), corresponds generally to the graded land classification on the land cover map. This area retains the natural features of a pine flatwoods with modification of drainage, streets and roads. Hammock areas mark the creeks and their tributary beds east of the coastal ridge. To the west hammocks are bay maple, pine, sabel palm or maple hammocks. Areas in which natural plant communities are not discernible are classified as urban.

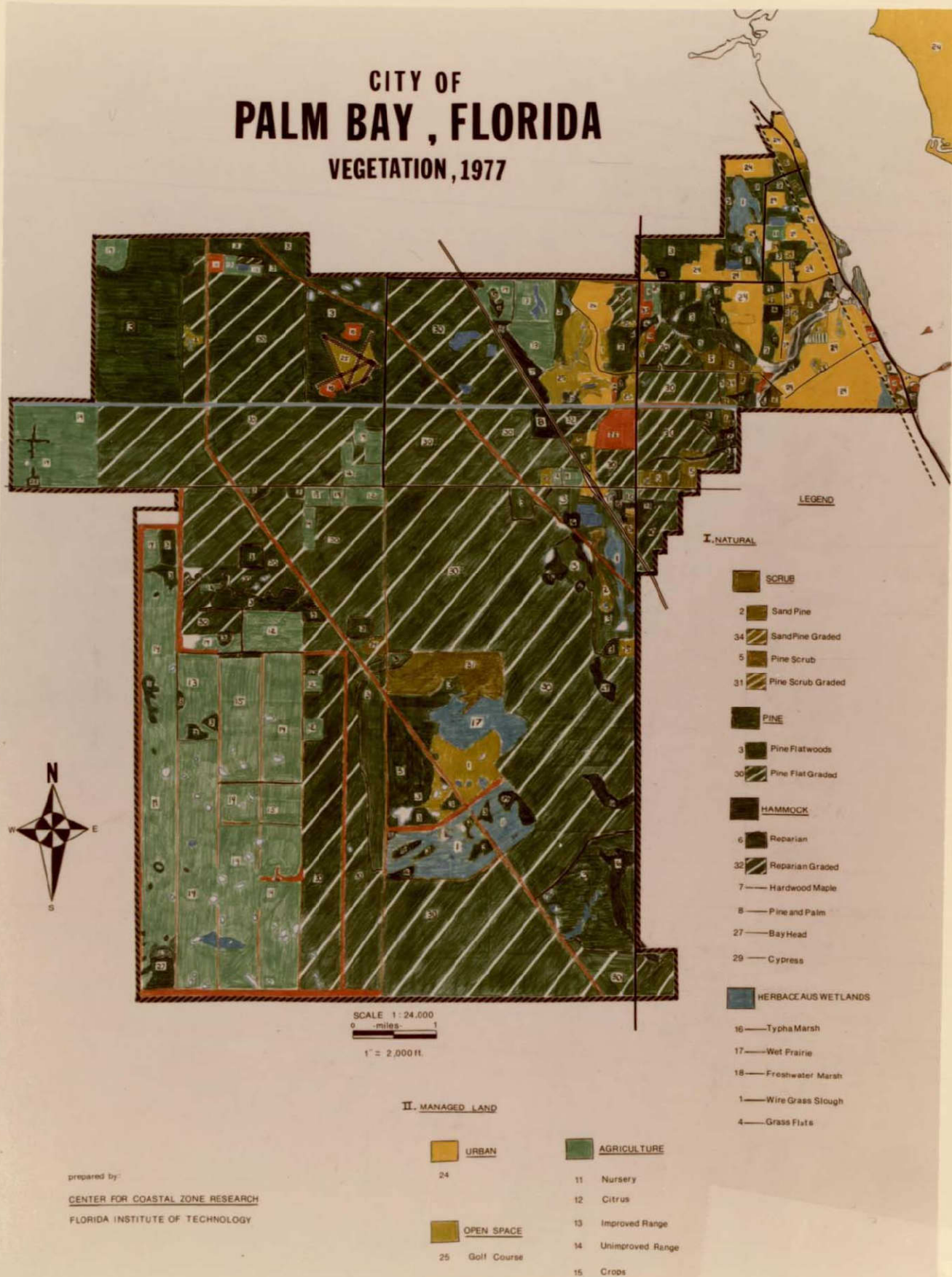
5.4.0 Existing land use map.

5.4.1 The classification of land into functional uses is described in Figure 14. A discussion of each land use classification listed in the map legend is found in appendix II. Table 4 lists each land use and the area occupied in the city as planimetered.

5.4.2 The most significant land use in the City of Palm Bay (44%) is unoccupied residential homesites primarily west of Babcock Street south of Palm Bay Road. Undeveloped land, or land not currently in urban or agriculture use accounts for 30% of the land available in the city. Eighteen percent of the Palm Bay's total area is devoted to agriculture, pasture, crops, etc. Urban areas, residential, commercial and institutional constitute 6.8% of the total area.

FIGURE 14

CITY OF PALM BAY, FLORIDA VEGETATION, 1977



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Table 4

EXISTING LAND USE - CITY OF PALM BAY

	(Acres)	Percent of Total Area
2e Graded Land .	17,727.05	43.77
2c Undeveloped Land	12,062.21	29.78
4+ Improved pasture	5,198.49	12.83
1a,b Single family,	1,463.28	3.61
4g Unimproved pasture	800.41	1.97
3c Institutional	685.38	1.69
4b Crops (Hay, row)	625.08	1.54
4a Citrus	402.88	.99
2b Managed open space	320.76	.79
4d Farm residence	275.70	.68
1d Mobile home	211.76	.52
3b Industrial, Manufacturing	205.00	.51
4c Dairy	166.99	.41
3a Commercial	132.82	.33
23 Parks and recreation	75.01	.19
1c Multi-family	66.39	.16
4e Utilities	44.40	.11
3d Plant Nursery	21.48	.05
Excavation	12.59	.03

5.5.0 Accuracy Analysis

5.5.1 Results of grid analysis of the LSDP, IMAGE 100 and ground truth are recorded in Table 5 . The first LSDP analysis was based upon intuitive assignment of land use categories to line printer characters. The second set of results refer to analysis in which land use was assigned based upon frequency of occurrence of each character as compared to the ground truth map. A second IMAGE 100 analysis using a modified designation of the pine land theme was undertaken only in site I. Results were less reliable than the original analyses.

5.5.2 A comparison of results from Table . 5 show that the IMAGE 100 program produced the highest efficiencies. Accuracy was consistently higher at site II (the hammock area) throughout the investigation.

TABLE 5

Summary Efficiency Analysis of remotely sensed data on test sites as compared to detailed ground truth.

Site	Dominate Land Use	I LSDP	II LSDP	IMAGE 100	IMAGE 100
Site I	Pasture	55.00 %	63.60%%	67.50 %	59.50 %
Site II	Hammock	53.25 %	60.0 %	79.25 %	

6.0 Discussion

6.1.0 Comparison of LSDP and IMAGE 100 mapping procedures.

6.1.1 The areas classified by the two LANDSAT programs differ in percentage of the area covered and in the classifications themselves. A comparison of Tables 2 and 3 show a difference of 6.7 percent in the percentage of the total area classified on the LSDP and IMAGE 100 maps. The LSDP (75.3 percent) is higher than the IMAGE 100 (68.6 percent). The LSDP program seems to be more efficient in the classification of water particularly in the Indian River. The IMAGE 100 program also recorded a conflict character for water overlaying marsh lands. Conflicts occur when there is an overlap in training. However, this designation could be useful in recording the seasonal variation of ground water levels.

6.1.2.0 A comparison of land cover classifications used for the three final maps is found on Table 6. The regional land cover maps were used as the basis for comparison. The origin of each classification system varies from ground truth interpretation of areial photographs, to user selected themes on the IMAGE 100, to machine selected themes based upon statistical analysis of spectral information (LSDP). Areas classified as marsh lands on the IMAGE 100 and ground truth maps were classified the same as hammock or unclassified in the LSDP.

Table 6 Comparison of Land Cover Classifications from
IMAGE 100, LSDP and Ground Truth.

IMAGE 100		Ground truth	LSDP
1. Pineland !		Sandpine ridges Pineflat woods Pine scrub	+ poorly drained land sparse vegetation
2. Urban recent established	· Θ -	Old field Urban vegetation and buildings Pine flatwoods, graded Pine scrub, graded Sand Pine, graded old field with street and drainage	0 cleared and dirt roads, levees
3. Crops "		Nursery Citrus	
5. Hammock \$		Cypress Bay maple heads Exotic plants Reperian hammocks Pine palm hammocks Maple	\$ hammock dense pine
6. Water *		Estuary Perennial ponds Freshwater stream Borrow pits Intermitant ponds	/ water % water —
7. Marsh >		Wet prairie Wire grass slough Typho marsh Freshwater marsh	o water in sloughs # sloughs
8. Pasture %		Range improved Range unimproved	* pasture
Unclassified		Unclassified Marine grassbeds Class II waters Class III waters Managed open space Beach dune Mangrove	unclassified urban (residential) marsh Borrow pits fresh water streams

** Symbols or numbers refer to designation on theme prints or legends of each map.

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- 6.1.2.1 The collection and mapping of ground truth information is an expensive and time consuming operation but classification can be easily established depending upon the purpose of the map. The LSDP program requires no user machine interaction but the results are difficult to interpret on a detailed level. General and "broad brush" land cover patterns are evident. However, the classification did not have clear cut meaning when compared to ground truth. Urban areas or highly reflective surfaces were not classified. LSDP seems especially sensitive to water surfaces and may also indicate to some extent surface water characteristics; drained versus undrained land.
- 6.1.2.2 The themes for the IMAGE 100 map were selected to represent the eight most common land uses in the study area, and groupings of the ground truth map classifications. The efficiency of this program was highest in the area of mixed land use classification. The pasture area, while classified by use may have contained unsurveyed vegetation. In addition land cover surveys of this area were completed in the spring and summer of 1977. The imagery was the same area four years earlier. Classifications were compared to Mark Hurd aerial photograph 1973-1974 for the pasture site. Modifications, in land cover, however, are probable as cattle are removed from pastures, vegetation chopped or drainage patterns altered.

6.1.2.2 continued

Such changes would tend to be more wide spread in the pasture area than the hammock area (Site II). A conflict character was recorded in areas where pine lands were interspersed with residential development or graded land. These conflicts characters seemed to correspond to the land cover categories of natural vegetation with modifications. Dense pine lands were sometimes classed as hammocks and pine scrub with little ground cover was classified as pasture occasionally. No differentiation could be distinguished between improved and unimproved pasture.

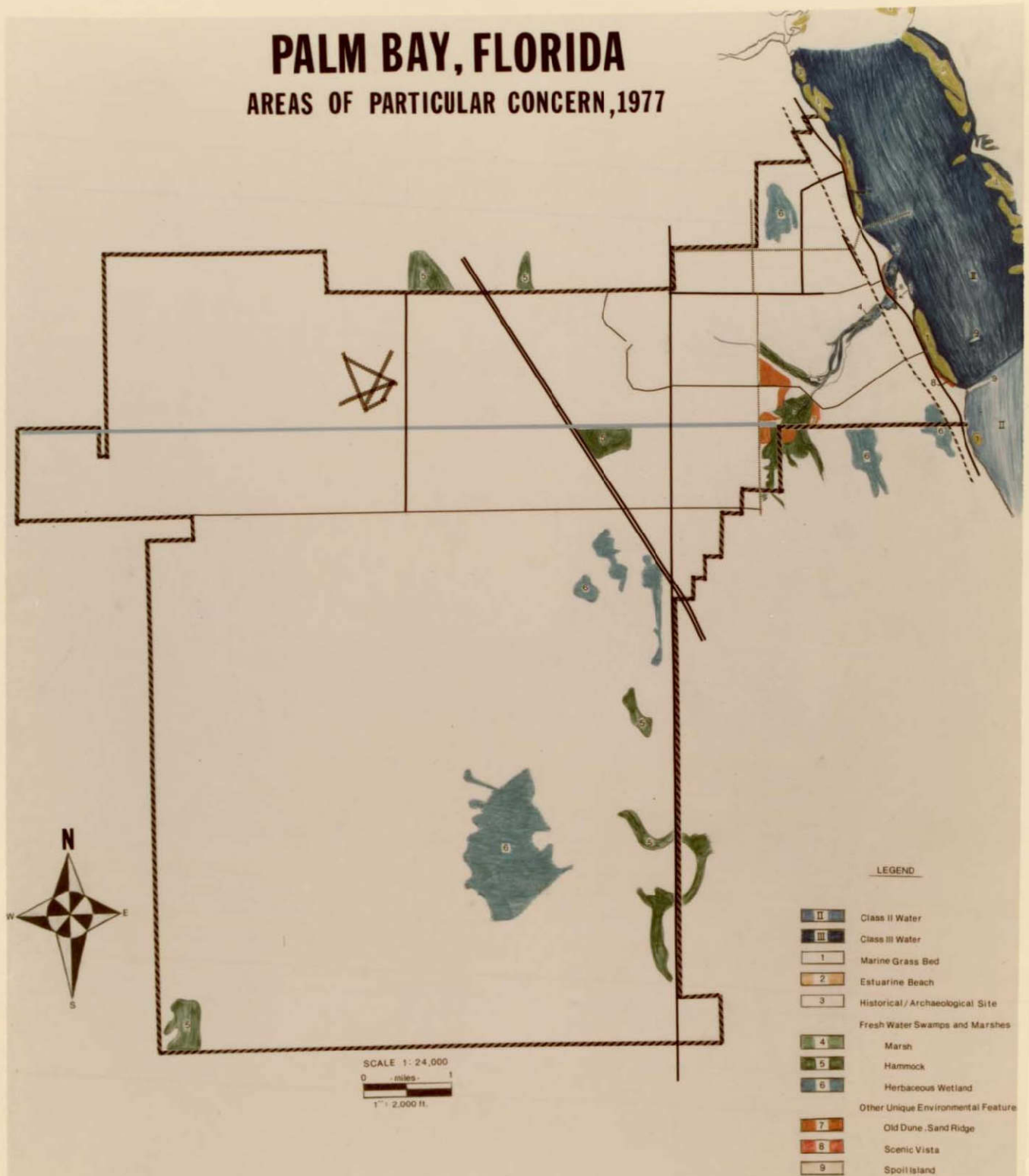
6.2.0 Application of Landsat information to vegetation and land use maps for the city of Palm Bay.

6.2.1 Land use and land cover maps were prepared simultaneously with the LSDP and IMAGE 100 analysis. Information from each map was compared against the other and field surveys undertaken to confirm assumptions. The computer analysis results were used to flag areas of the land use and cover maps for further survey and to provide documentation of classifications assigned on Particular Areas of Concern Map (Fig. 15). The herbaceous wetlands and hammocks depicted on the map were confirmed by their classification on all three maps produced during the study.

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FIGURE 15

PALM BAY, FLORIDA **AREAS OF PARTICULAR CONCERN, 1977**



prepared by:
 CENTER FOR COASTAL ZONE RESEARCH
 FLORIDA INSTITUTE OF TECHNOLOGY

7.0 Conclusions

7.1 LANDSAT information from the LSDP is best used for determining general development patterns. LSDP analysis requires little user input for map generation but through familiarization with the area is necessary to interpret the data. Themes presented may not correspond, directly to the map (i.e. land use or land cover).

7.2 IMAGE 100 theme mapping requires initial familiarization of the user with the region under investigation. Themes, however, can be designated based upon a training site typical of the land cover or use desired on the map. Interpretation is, therefore, based upon a priori information. Classifications are more functional since they are based on a known theme.

Two classifications for urban use were employed in an attempt to designate long established neighborhoods versus recently developed areas. This system showed some promise but would require further analysis to prove its effectiveness.

7.3 The IMAGE 100 analysis proved for this study to be the more useful of the two programs for designating land cover. The LSDP program required little user input but themes presented were difficult to relate to vegetation communities delineated on the ground. The IMAGE 100 program

7.3. continued

classified less of the total area than LSDP but the information when mapped had more meaning. The IMAGE 100 themes represented classifications identified by ground truth. The LDSP and IMAGE 100 program were more useful in mapping land cover rather than land use.

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Vegetation - Land Cover Classification

The land in Palm Bay as seen from aerial photographs and satellite pictures is covered both by natural vegetation and humanly managed systems. During this study both have been mapped. Environmental land use cover or vegetation is mapped in figure XI and existing land use classified by human use is found in figure XII. Each classification is described by number key as designated on the map.

Environmental land use.

1. Wire grass slough areas are usually interspersed in pine flatwoods. Subsoil tends to be clay or hardpan which retards the percolation of water. Moisture is held or ponded as if in a clay bowl. Shallow rooted grass which can withstand the effects of ponded water form a meadow or clear area in the pine land.
2. Sand Pine ridges are undulating sand hills of well drained soils in long low ridges east of the coast ridge. Typical vegetation is sand pine, scrub oaks, saw palmetto and some longleaf pine.
3. Pine flatwoods are the most prevalent natural land use in the city. These areas include long leaf or slash pine with an understory of scrub palmetto, gallberry and myrtles. The soils are usually nutrient poor and sandy.
4. Grassbeds and flats in the shallows of the Indian River are the most productive portions of the river. The bottom of fine sand and grasses provide a rich supportive environment for shellfish development and spawning areas for fish. These estuarine waters act as a nursery during the early stages in the life cycle of many marine animals. The warm protected hatchery then provides a basis for the development of an intricate web of life, from the smallest algae to porpoise and sharks. Many animals spawned in the river complete their life cycles in the Atlantic. For that reason, off shore fishing as well as local recreational and commercial fishing and the shellfish industries depend upon the health of the Indian River. The clam and oyster industry in Grant finds its basis on the optimum water quality of the rivers southern portion. The State of Florida also operates public oyster beds along the river in Valkaria and clams are taken from beds in the same general area.

Marine grass beds in the Palm Bay area are primarily rooted eelgrass and *Diplanthera*. These flats tend to stabilize the bottom and trap sediments suspended in the water.

5. Pine scrub vegetation is predominately low slash pine with an understory of scrub oaks, and little ground cover. Soils tend to be dry white sand.
6. Riparian Hammocks are tall dense forests lining the banks of creeks or intermittent streams. These usually occur on low alluvial peaty soils and are subject to periodic flooding. The vegetation is mixed, cabbage palms, oaks, hickories, bays, and maples. Scattered among these dominate species are mulberries, hackberries, stopper trees and strangler figs.
7. Maple hammock are stands of red maple interspersed with other hardwoods, oak, hichory. The dominate tree species is maple.
8. Pine-Palm Hammocks are found as transition zones between the upland pine flat woods and the hammocks. Typically pine-palm hammocks are found as stands west of I-95, silhouetted on wet prairies or pastures.
9. Maple in dense stands is found along Turkey Creek in areas of long term sediment build up.
10. Old field vegetation is the plant groups which populate land which has been plowed, graded and abandoned. It is the collection of fast growing grasses and herbaceous shrubs which cover the ground after clearing operations. This plant community is found in vacant lots, road sides and abandoned constrution sites.
11. Nurseries are commercial plant propagation centers with rows of shrubs and trees in the ground or cans for wholesale or retail distribution.
12. Citrus Groves are areas discernible on aerial photos devoted to the culture of orange, grapefruit and other citrus trees in rows producing fruit for either private or commercial use.
13. Range - unimproved is pasture lands of largely native, natural vegetation for the grazing of domestic animals. The area however, has had minimal site preparation, clearing, drainage, mowing, chopping or chemical fertilization or pesticide application.
14. Range - improved is pasture lands with distinguishable site preparation. The land has extensive systems of drainage for water table control and native grasses may be replaced by pasture grasses.
15. Croplands include hay fields, large gardens discernible on a aerial photographs and a strawberry farm.
16. Typha (cattail) marsh is found along Turkey Creek and makes with the predominate vegetation on the sediment islands forming in the Turkey Lake area. Cattail are also found in low areas and ponds of the uplands, prairies and marshes.

17. Wet Prairie lands mark the transition from the pinelands to the marsh on the slope from the Atlantic Coastal ridge to the marsh lands surrounding the St. Johns River. Ground water is often near the surface for periods of several weeks or months per year. Vegetation is shorter than marsh vegetation.

18. Marshes (freshwater) are seasonally to continually inundated areas with various species of sedges, rushes, grasses, reeds, and other herbaceous plants. Marsh soils are usually alluvial mucks and peats. These areas include sawgrass and juncus marshes as well as small areas of *Spartina* sp.. Marshlands covered large portions of the St. Johns' Basin. Currently areas in the western portion of Palm Bay as well as isolated pockets within undeveloped areas and unimproved pasture are classified as marsh vegetation.

19. Indian River - Class II waters. The waters of the Indian River south of Cape Malabar, (about a mile south of Turkey Creek), are designated by the State of Florida as Class II waters, a shellfish harvest area. The quality of water is generally good but not suitable for drinking because of the chloride content but sufficient for the safe harvest of clams and oysters.

The lands bordering the river in the shellfishing area exhibit low population densities and minimum shoreline development. Kid Creek, Goat Creek and Trout Creek feeding into the Indian River at this point are also classified as Class II waters. They deposit little urban runoff or sedimentation. No sewage discharges into the river here from sewage facilities but septic tank fields do contribute some flow. Increase of human effects would endanger public health in shellfish harvesting property areas and adversely affect the viability of the river. Several times a year following periods of heavy rainfall shellfish harvest is restricted by the Brevard County Health Department. Runoff from urban areas carrying large numbers of bacteria contaminate the oyster beds. A period of several days or weeks is required to allow bacteria counts to assume natural levels.

20. The northern section of the Indian River in the study area is classified as Class III waters. Water not suitable for drinking water, or shellfish harvest but suitable for recreation and the propagation of fish and wildlife.

The area of the Indian River north of Cape Malabar has been most affected by human development. The areas nearest the shoreline display the greater affect, while those areas in the center of the river are least affected. The region of the river near the outfall of Turkey Creek shows signs of degradation. It has been designated a number one priority problem by the 208 Water Resources Study Committee. The water flowing into the river carries a runoff load rich in nutrients from lawn and agricultural fertilizer capable of causing algae blooms and eutrophication. The upland runoff from

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agricultural and storm drainage, golf courses and sewage treatment carries additional nutrient loads. Algae blooms and subsequent depletion of oxygen in the water may occur. Hyacinth eradication projects deliver chemicals which cause plants and grasses to die, drop to the bottom and decompose. These processes can cause an oxygen deficiency in the creeks and canals. Then the oxygen levels become so low the quality of water decreases and fish kills are reported.

In summary then the Indian River as it borders Palm Bay area acts as the receiving body for those natural flows of water from the Atlantic Coastal Ridge as well as the recipient of urban and agricultural runoff from drainage projects. The quality of water varies with the amount of urbanization on the rivers shores. A unique natural resource is found in the productivity, beauty, economic contribution of the shellfish industry and recreation potential.

21. Fresh water stream Turkey Creek with its five branches and tributaries are a major feature of the City of Palm Bay. Two branches of the creek drain north from Malabar. The Melbourne Tillman Drainage District main outlet canal (C-1.) joins Turkey Creek east of Babcock Street. Another branch of the creek crosses Babcock Street, drains east under Knecht Road then into the creek. Yet another branch drains south east from Palm Bay Road and several drainage ditches. This branch also accepts effluent from the Port Malabar Utilities Sewage Treatment Plant and polishing ponds of the Harris Corporation.

Banks of Turkey Creek are often lined by aquatic weeds, water hyacinth, pickerel weed, arrowhead and cattails. Algae blooms have been reported frequently in the stream.

22. Borrow pits and ponds. Borrow pits are the water filled reservoirs which result from the excavation of sand, soil, clay or marl. A series of these usually rectangular ponds alternate on either side of I-95 and other areas in the city. Soil materials dredged from these areas are used as fill low laying areas for the construction of road beds and building sites.

Ponds are naturally occurring low areas in the uplands, prairies and marshes filled with water most of the year.

23. Intermittant ponds are shallow water filled areas with water above the ground surface most of the year. These areas may be covered with flags or other plants which can tolerate long periods of inundation.

24. Urban vegetation and buildings. The designation is used to mark areas where natural vegetation patterns are no longer recognizable. Pavement, street, roads, houses with landscape materials characterize the system.

25. Managed open space is land which has been partially or completely cleared and maintained by mowing, fertilization and some irrigation. This category includes golf courses, large

playing fields similar to those surrounding schools.

26. Exotic plants have been introduced to the Palm Bay area during the past fifty years. These plants originated in areas of extended evolutionary development and competition. They have a competitive advantage when placed in Central Florida a ecosystem of relatively early stage of development. Brazilian Pepper, Melaleuca and Australian pines are therefore, able to reproduce and out compete native vegetation for light and space. Brazilian Pepper trees line the Indian River, many vacant lots and road sides. Australian pines dominate the north side of the bay, parts of Turkey Creek, and have spread out from planted wind breaks. Melaleuca or pock trees are a problem in south Florida where dense forests have been established in the Everglades. A few stands have been established in sloughs and wetlands in Palm Bay.

27. Bay - Bay Maple Heads are nearly circular hammock like areas which dot the area west of I-95. These thickets of hardwoods include sweetbay alone or in combination with red maple.

28. Beach dune - There are no beach dunes in Palm Bay.

29. Cypress trees are found in a small area just off Babcock Street in the partially developed areas on the Southeast portion of the city. In the natural condition cypress domes or strands are found in low basins with a clay subsoil. Water is ponded beneath the trees for much of the year. In Palm Bay the cypress areas have been drained.

36. Mangrove trees line the Indian River South of Palm Bay. There is however no mangrove vegetation in the city.

37. Unsurveyed vegetation

The following classifications were used for areas with a combination of urbanization and discernible native vegetation patterns.

30. Pine flatwoods which has been cleared and graded with some street construction.

31. Pine scrub land with streets and drainage.

32. Hammock areas with streets, homes and drainage.

34. Sand pine areas with urbanization

35. Old field areas with streets and drainage.

LAND USE CITY OF PALM BAY

Land use in the study was designated by aerial photography and represents actual areas occupied as of July 1977. Land use designation therefore may not correspond to land ownership or actual lot lines

1. Residential:

- a. Single family, low density: areas of one or possibly 2 family houses with densities of 1 - 4 units per acre.
- b. Single family, medium density: areas of predominately residential units with greater than 4 units per acre.
- c. Multifamily: areas of units occupied by generally three or more families.
- d. Mobile homes: areas occupied by trailers.

2. Open Space:

- a. Parks and recreation areas: This designation included areas of playgrounds, baseball fields.
- b. Managed open space: These areas included graded areas maintained and mowed including golf courses, roadsides and green areas.
- c. Natural areas: This designation includes all land which has not been improved for use or has been used for a period of time sufficient to achieve a second or third stage in environmental succession.

3. Non-residential use:

- a. Commercial: This area includes strip commercial areas, shopping centers and other business areas.
- b. Industrial, manufacturing: This designates areas of detached industrial plants and small manufacturing operations. These areas designate the area in buildings and structures.

- c. Institutional: These areas include schools, churches, local, city, state and federal buildings and installations.
- d. Excavation: This designation refers to sand, marl, and gravel pits and mines.
- e. Graded land: This includes land which has been scraped in preparation for construction and/or has been prepared for development with roads, power lines and drainage structures in preparation for residential development. Two designations were recorded high and low density depending upon the intensity of the site preparation.

4. Agriculture

- a. Citrus: Groves of orange and or grapefruit trees.
- b. Crops: Fields of hays, grasses or row crops.
- c. Dairy: Improved pasture for dairy cows.
- d. Farm residence: residential and other building associated with large agriculture operations or total area of agriculture estates.
- e. Nursery: commercial plant propogation operation.
- f. Improved pasture: This includes areas where natural vegetation has been altered through drainage irrigation, fertilization or chopping for the grazing of domestic animals.
- g. Unimproved pasture: Native pasture for which there has been little site preparation for the accommodation of domestic animals.